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Daily flights of Rooks *Corvus frugilegus* LINNAEUS, 1758 and Jackdaws *Corvus monedula* LINNAEUS, 1758 wintering in Cracow

[Pp. 735—772 and 12 text-figs]

Codzienne przeloty gawronów *Corvus frugilegus* LINNAEUS, 1758 i kawek *Corvus monedula* LINNAEUS, 1758 zimujących w obrębie Krakowa

Ежедневные перелёты грачей *Corvus frugilegus* LINNAEUS, 1758 и галок *Corvus monedula* LINNAEUS, 1758 зимующих в пределах Кракова

Abstract. The behaviour of Rooks and Jackdaws wintering in Cracow was observed in two seasons, 1968/69 and 1969/70. Five flight routes were distinguished, of which the one extending over a distance of 15 km, from Mydlniki to Rybitwy, was given most attention. This route led along a valley protected by hills, raising 40—70 m. above its bottom, on the north and on the south. The degree of dependence of the flights to the feeding grounds and roosts on sunrises and sunsets was established. An attempt was made to point out the relation between the type of flight (rectilinear, undulate, forced and soaring) and the force and direction of the wind. The behaviour of birds was observed in the places of rallying, feeding and roosting. The food requirement of the whole winter population of Cracow was worked out and it is 618×10^6 kcal. which corresponds to the consumption of 772 tons of potatoes.

CONTENTS

I. PROBLEM

Every morning and evening Rooks and Jackdaws flying in flocks were seen out of the third-floor windows of our flat, overlooking the neighbouring houses. When it appeared that the birds flew regularly along Dzierżyńskiego Street (Fig. 1 D) and that they could be watched quite easily through the windows of the flat, systematic observations were started. At first we were concerned only with the exact determination of the time of flights. Soon it occurred to us that we should also determine the numbers of the flying birds. A few trials

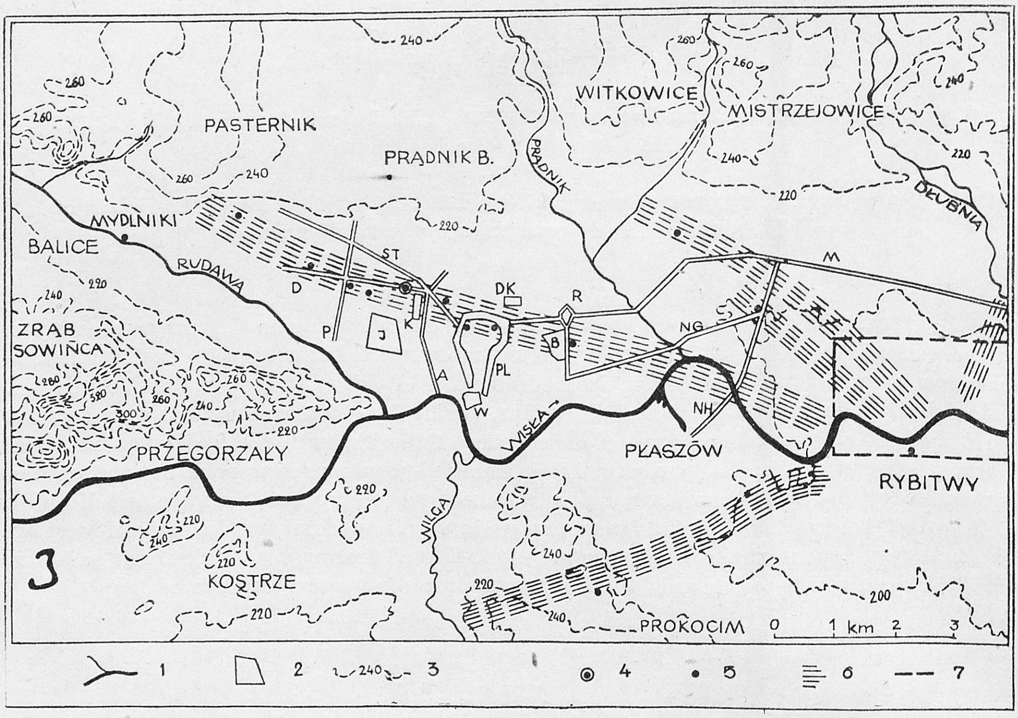


Fig. 1. Main flight routes in the old Vistula Valley and Rudawa rift valley. Some streets and parks of Cracow are plotted on the map as landmarks. 1 — rivers, 2 — parks and greens, 3 — contours, 4 — main observation point, 5 — other observation points, 6 — flight routes, 7 — roosting sites (details in Fig. 9). A — Avenues, B — Botanical Gardens, D — Dzierżyńskiego Street, DK — railway station, J — Jordan Park, K — Krakowski Park, M — Mogilska Street, NG — Nowogrzegórzecka Street, NH — Nowohucka Street, P — Piastowska Street, Pl — Planty, R — Powstańców Warszawy Circus, ST — 18 Stycznia Street, W — Wawel

proved that this was relatively easy to do on condition that two persons counted the birds, one at a window looking on the south and the other on the north side, for the house stood just under a broad track of flights. Here was our main observation point.

Later, other sections of the flight route were covered by observation, also. For this purpose 11 observation points were gradually fixed over the distance of 15 km from Mydlniki in the west to the Park at Mogiła in the east. Mydlniki was the stage of the morning flights where the last groups of birds stopped in their feeding grounds (Fig. 1). In the park at Mogiła the birds used to roost in the trees in 1968/69. It was also found that there were other four flight routes, which extended from the south and north, to Rybitwy, where they met the east-west route. One of them led over Płaszów, another was parallel to the River Prądnik, still another began in the meadows at the crossing of Nowohucka Street and Nowogrzegórzecka Street at Łęg (Fig. 1 NG and NH), and the last one ran over Mogiła. These routes were dealt with only sporadically.

Excursions were made by car into the environs of Cracow in search of Rooks and Jackdaws. We reached the Niepołomicka Forest via Prokocim and Wieliczka in the east, Mogilany, Grodzisko and Tyniec in the south, Modlnica and Ojców in the north, and Bielany, Liszki, Balice, Zabierzów and Rudawa in the west. On occasion we also visited the town refuse-dump at Przegorzały on the Vistula, the place of intense feeding of the birds. These excursions made it possible to gather information as to where the birds under study scattered in the daytime and where they gathered together before flying to their roosts.

The flights of birds depend to a great measure on the configuration of the area; hence, the very varied relief of the Cracow region supposedly had an effect on the flight routes. Changeable weather conditions, especially the winds, determine the behaviour of flying birds or their mode of flight. Finally, the question arises how the autumn and spring migrations of Rooks and Jackdaws present themselves against these everyday flights.

Observations were carried out from September to March in the seasons 1968/69 and 1969/70. In the first season the investigation was systematic and various in character, in the second season it was confined to the analysis of the unsufficiently elucidated problems which had emerged in the course of the first series of observations.

II. TOPOGRAPHY OF THE AREA AND MOVEMENTS OF AIR MASSES

The area of the town of Cracow, characterised by its very varied relief, is traversed by the old valley of the Vistula. The valley is up to 8 km. in width near Pleszów, narrows considerably towards the west, and at Wawel Hill branches into two narrow rift valleys, one of the Vistula and the other of the Rudawa (Fig. 1). The sides of the Vistula and its left-sided tributaries, Rudawa, Prądnik (Białucha) and Dłubnia, are formed by terraces, 3—6 m. in height,

built of late glacial and Holocene deposits. The north and north-western part of the old Vistula Valley is limited by the slope of the Minor Polish Upland, which at places reaches 70 m. in absolute altitude. The broad ridges of Pasternik, Witkowice, Mistrzejowice and Krzesławice have been distinguished in this slope. The rift valley of the Vistula is separated from that of the Rudawa by the Sowiniec Horst, which overtops them by 80—150 m. The southern part of the old valley of the Vistula is bordered by the Cracow Plateau, which extends from Kostrze to Prokocim and rises 30—60 m. above its level (TYCZYŃSKA, 1967).

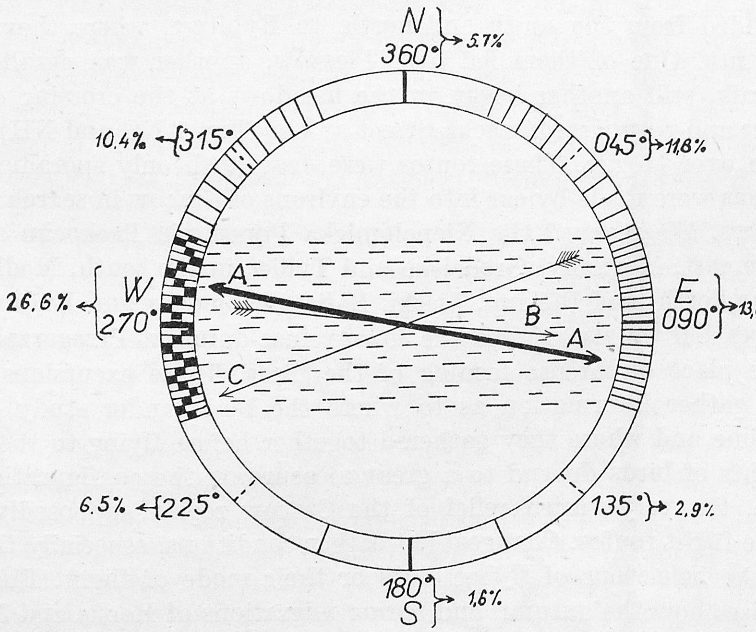


Fig. 2. A comparison of the winds prevailing in the main zone of flights and the direction of flight routes. The frequency of winds blowing from different directions is expressed in percentages of the number of days in the year and represented by the suitably hatched segments of the ring. A—A — direction of morning and evening flights, B — direction of spring migrations, C — direction of autumn migrations

The climate of Cracow is as much diversified as the relief of its area. The old Vistula Valley, stretched along the long axis of the town and edged by elevations of various altitude on both the northern and the southern side, creates unique conditions for winds in respect of their direction and force. In the annual scale the westerly (26·6% of days), easterly (13·6%), north-easterly (11·6%) and north-westerly (10·4%) winds prevail here, whereas the southerly (1·6%), south-easterly (2·9%), northerly (5·7%) and southwesterly (6·5%) winds occur less frequently. There are relatively many days of calm (21·1% of days; Fig. 2). The westerly and easterly winds predominate in the old Vistula Valley and the south-westerly and southerly winds in the valleys of the left-sided tributaries.

The weakest winds blow at the bottom of the old valley of the Vistula, the strongest ones on the elevations. In addition, in this last case there are more days of strong and very strong winds, whereas at the bottom of the Vistula Valley the number of days of calm is several times as high as that for the surrounding hills (HESS, 1967).

III. FLIGHT ROUTES

It may be stated on the basis of the observations made at eleven points that in the evening the Rooks and Jackdaws fly more or less straight from Mydlniki, along Dzierżyńskiego Street, then across Karmelicka Street, over the northern portion of the Planty *, up to the Botanical Gardens (Fig. 1 D, K, Pl, B). Here the flight route turns slightly to the south-east and extends over the Vistula to Rybitwy, where the birds stop at the final rallying site before roosting. The width of the flight route is 400—600 m. Never, however, do the flocks of birds fly spread over the whole width of the route, but, on the contrary, they always crowd together in considerably narrower tracks, and two or even three such elongated groups may appear side by side on the route.

The route corresponds exactly to the rift valley of the Rudawa and the old valley of the Vistula and, in its terminal portion, it keeps to the narrow zone of the present Vistula. As will be seen from the above-mentioned considerations on the anemological conditions (HESS, 1967), for their flights in Cracow the Rooks and Jackdaws use the quietest possible air zone, sheltered over a great distance by high hills from the north and south.

Since 63% of the Rooks and at least 14% of the Jackdaws nesting in Poland migrate to the west, and other birds, coming for winter from the east, take their place (BUSSE, 1969), the question arises whether each year the route of daily flights presents itself at once like that described above, or whether the birds discover it afresh and by degrees each season. The same refers also to the rallying sites and roosts of these birds. Unfortunately, it has not, as yet, been possible to decide whether the Rooks wintering in Cracow are exclusively immigrants and whether they come here from all over Poland or from the close environs of Cracow only. Writing about the distribution of the breeding colonies of Rooks in Poland, DYRCZ (1966) informs that the census showed the presence of 1786 colonies and about 211,000 nests in 1962 and 1963. It is assumed on the basis of similar calculations that about 300,000 pairs of Rooks nested in Hungary (VERTSE, 1943). If the population of Rooks and Jackdaws wintering in Cracow is of mixed derivation, the above-mentioned calculations by DYRCZ do not allow us to estimate, even roughly, the percentage share of the specimens of local origin.

Observations carried out in August, September and at the beginning of October 1969 (Table I) throw some light on the choice of the route by the birds.

The Planty are town gardens which in the form of a ring surround the Old City of Cracow (see Fig. 1. Pl, Fig. 8).

No Rooks were met with either on the flight route or in the close environs of the town and in the town parks in the first half of August. Jackdaw flocks, however, not exceeding 80 specimens in number, flew regularly in the evening starting from 3 August. During these flights a few of the birds alighted on the roofs for a short time. Rooks appeared towards the end of August. A large amount of excreta found on some paths of the Planty on 1 September indicated that these birds roosted in large numbers in the neighbourhood of the post-office, in the centre of the town. They came there chiefly from the west and north, less numerously from the east and, surely, the fewest from the south. At the beginning of September flocks of several hundred birds each flew eastwards over the observation point in Dzierżyńskiego Street. These flocks gradually decreased in number and did not reach a considerable size before the second half of the month. The following data were provided from the observation point near the Botanical Gardens, more than 4 km. away from the previous point. Towards the end of August no birds but Crested Larks flew over this point in the evening. Later, flocks, which decreased gradually from 467 to 83 or 82 specimens, flew towards the Planty, i. e., to the west. At more or less the same time there appeared at first single birds tending to the east (12 and 15 specimens); next they became more and more numerous, but not until the number of birds roosting in the Planty decreased.

Table I

Early-autumn evening flights. In the route analysed the Planty have a central position, the Botanical Gardens lying to the east and Dzierżyńskiego Street to the west of them (Fig. 1, B, Pl, D). In the column „Roost in the Planty" 100% denotes the full number of roosting birds, which I failed to express in figures

Date 1969	Botanical Gardens Flight to the		Roost in the Planty	Dzierżyńskiego Str. Flight to the East
	East	West		
29. 8.			?	
1. 9.			faeces on ground	573
2. 9.			„ „ „	320
4. 9.			100%	46
6. 9.		467	„	
9. 9.	12	151	„	
13. 9.			„	1852
16. 9.	15	83	„	
20. 9.			„	859
29. 9.	995	2	50%	.
4. 10.	3339	4	some dozens	
7. 10.	3063	21	absent	
8. 10.			„	1717

The foregoing observations may be summarised as follows: (1) In September the Rooks and Jackdaws roosted in the Planty. (2) They flew there from all sides not excluding the east and, later (6 September), the west. (3) Towards the end of September the number of birds roosting in the Planty decreased. At the same time the number of the birds flying eastwards towards Mogiła in the evening and westwards to the feeding grounds in the morning increased from about ten to several hundred. (4) The number of birds flying eastwards in the region of the Botanical Gardens in the evening was considerably larger than that of birds flying in the same direction over Dzierżyńskiego Street (Fig. 1 B, D). Nearly half of the birds, therefore, fed somewhere near the route between these two points and not exclusively at its western end, or they joined the main group over this distance. (5) The birds took whole September to fix the route corresponding to that of the previous year. A gradual change in the situation of the roost played a key role in this process. (6) The fixation of the route in the way of gradual changes may be explained either by the gathering of experience by the new population of birds or by the influence of the specimens that remembered the situation of the roost of the previous year and became leaders of the flock.

IV. TIME OF FLIGHTS

The gregarious flights to the feeding ground and back to the roosting site persisted for 7 months, from September to March. It may be stated on the basis of over 50 morning and 60 evening observations that the flights are characterised by a great regularity in respect of both the time and duration of their occurrence. The time of the flights is closely associated with the sunrises and sunsets (Fig. 3). They always begin much ahead of the appearance of the sun above the horizon or its descent below the horizon, and they linger on somewhat after these moments. When the morning passages begin, it is still quite dark. The flying birds are heard quite clearly, but only their silhouettes can be seen against a light sky. A few minutes later it is so light, naturally on a fine day, that visual observations are done without difficulty. The voices of Partridges (06^{30} — 1 December) and Blackbirds (05^{12} — 22 March, 05^{00} — 26 March and 04^{50} — 29 March) precede the commencement of the morning flights by several minutes.

The duration of morning flights differs markedly from that of the evening flights in that the former are much shorter. The morning flights last on the average 35 minutes (25—45). In March the flights extend in time and reach an average of 50 minutes. The evening flights average 67 minutes (42—100), this time being prolonged on the average to 116 minutes (98—145) at the end of February and in March. Generally speaking, the birds fly to their feeding grounds in a greater hurry than they return from them to the roosting site in the evening.

Since the numbers of birds flying in the morning and in the evening should, as a rule, be more or less the same and the duration of the flights changes, their

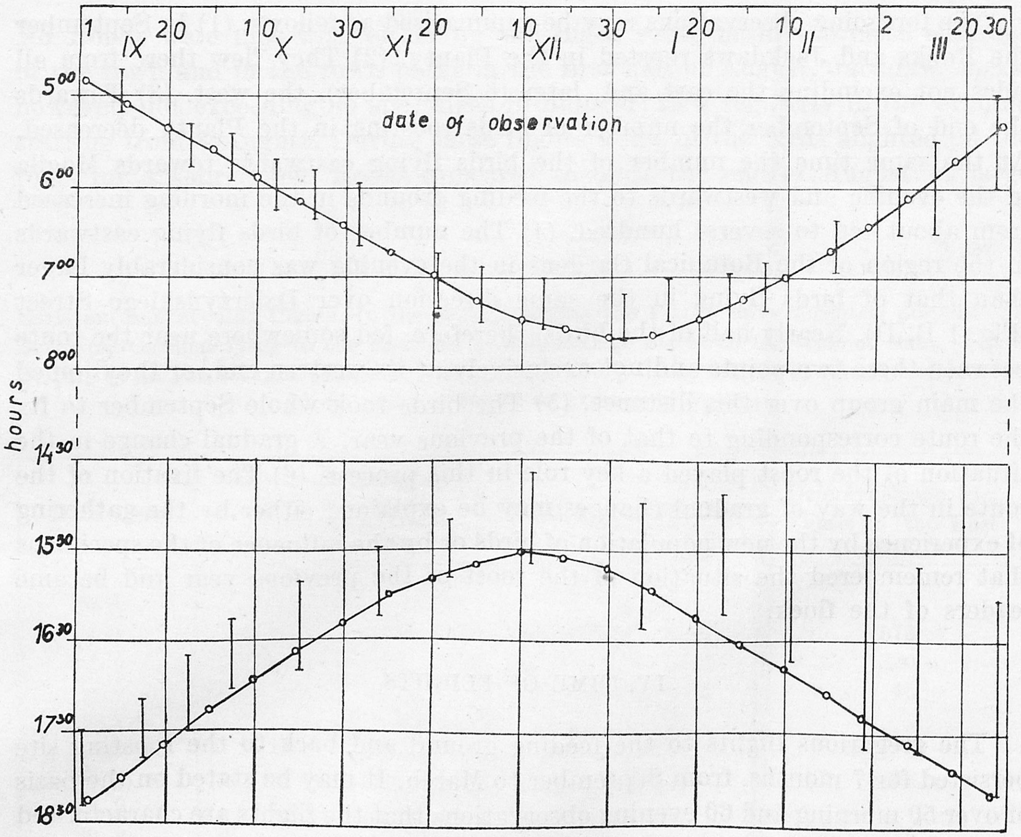
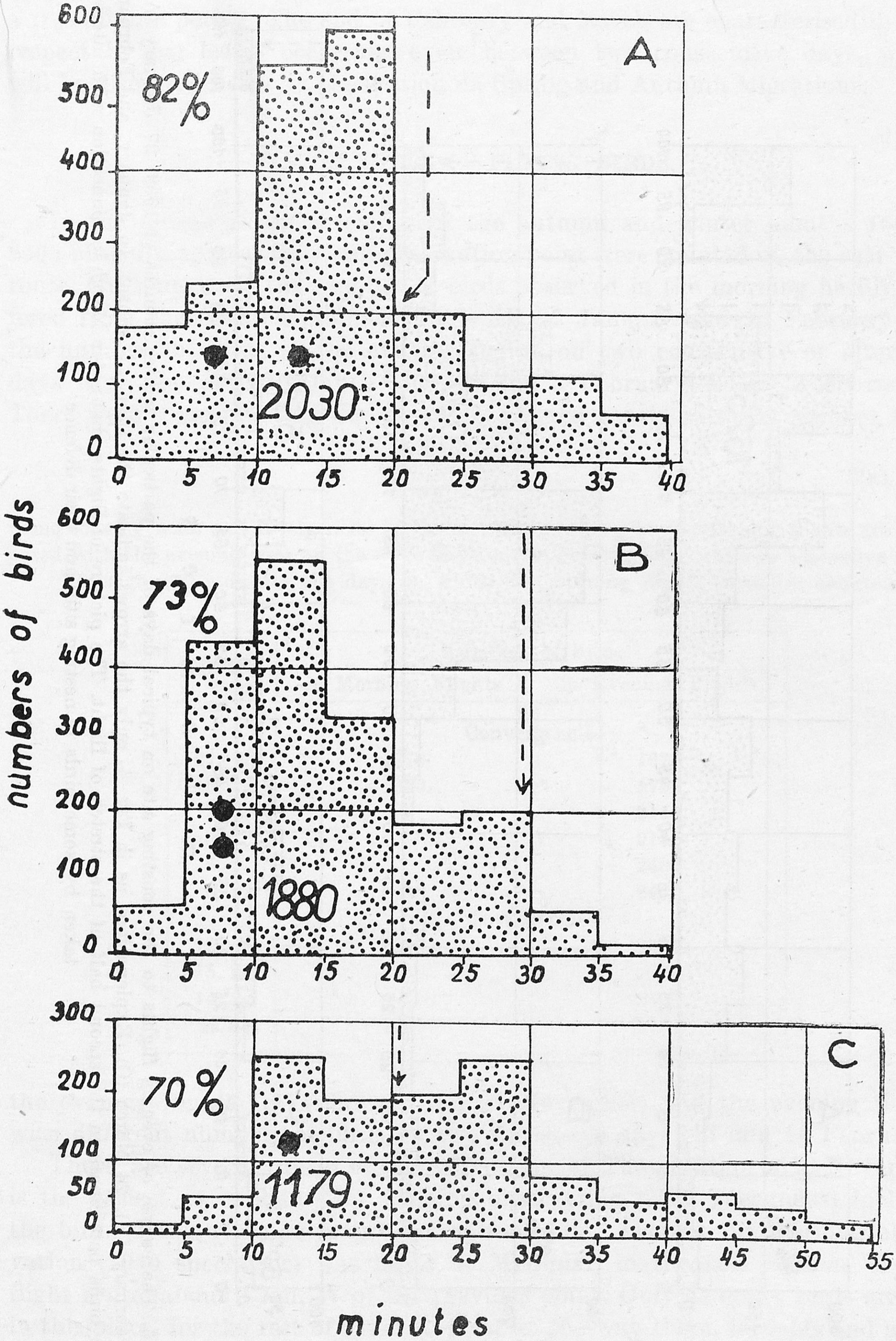


Fig. 3. Time and duration of daily flights. The upper curve connects the times of sunrise (circlets) from September to March, the lower — the times of sunset. The vertical lines represent the duration of each flight referred to sunrise or sunset (1968/69)

intensity must be different. This is very clearly illustrated by the graphs, in which the time of flights is divided into five-minute periods and the number of birds flying over the main observation point is given for each such period (Figs. 4 and 5). It will be seen from them that most of the birds move to the feeding ground in the first half of the train, whereas on the way back to the roosting site most of them fly in its second half. In the morning flights the maximum number of birds flying over within a five-minute period was about 500 specimens. In the second half of March this number decreased to about 200 specimens. This is not the case in so far as the evening flights are concerned, where the maximum numbers range widely, from 250 to 1000 specimens, in

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Fig. 4. The course of morning flights to the feeding ground on typical days of the particular winter months in 1969: 24 January (A), 14 February (B), 15 March (C). The number of flying birds is given on the ordinates and the flight duration, divided at 5-minute intervals, on the abscissae. The arrows indicate the sunrise and the black circlets flocks of 100—200 birds. In the upper left-hand corner is the percentage of the birds counted in the first half of the flight. The figure given in the graph is the total of the birds observed at the time of this flight



A
82%
2030
B
73%
1880
C
70%
1179
numbers of birds
minutes

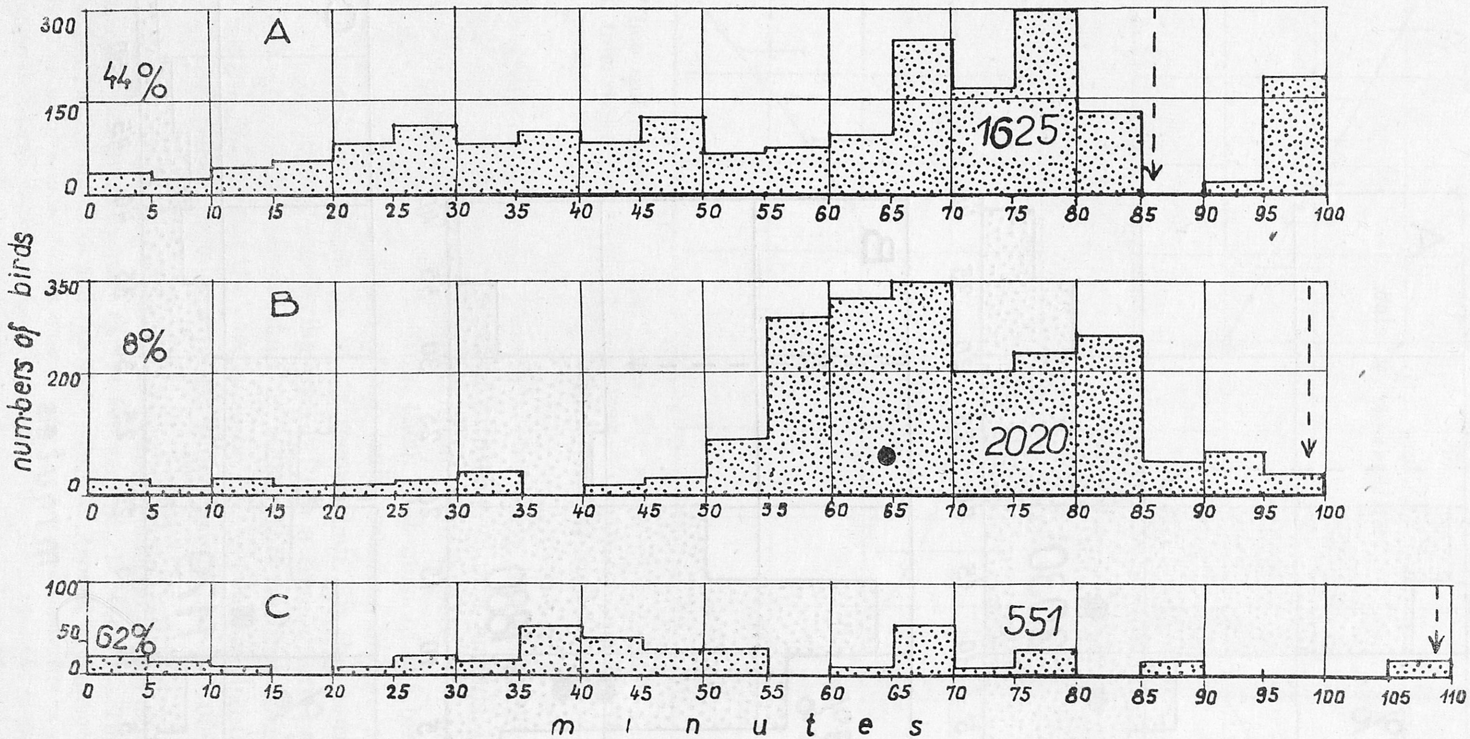


Fig. 5. The course of evening flights to the roosting site on typical days of the particular winter months of 1969: 27 January (A), 13 February (B), 24 March (C). Explanations as in Fig. 4, only the arrows indicate the time of sunset. In January and February most birds participate in the second half of the stretch of flight. The picture of flights changes in March in connection with interest taken by some birds in nesting sites and their defence

a five-minute period. The end of February and March are characterised in this respect by big leaps, occurring even between two consecutive days, which will be discussed below in the section on Spring and Autumn Migrations.

V. NUMBERS OF FLYING BIRDS

In the mornings and evenings of the autumn and winter months 1500—2500 birds flying over the main observation point were counted on the east-west route. On some days the number of birds observed in the morning hardly differed from the evening number (Table II, 27 January and 15 February), or the numbers of birds in the evening flights on two consecutive or alternate days were unexpectedly much alike (2 and 3 February, 6 and 8 February). There were some morning flights which differed considerably in number from the evening flights (11 February and 24 November) and the evening flights with different numbers of birds on two successive days (13 and 14 February).

Table II

Some convergencies and divergencies in the numbers of flying birds. Morning flights are compared with the evening ones on the same days or the evening flights of two successive days. The sign „?“ indicates the days on which the morning flights were not counted

Date	Numbers of Birds	
	in Morning Flights	in Evening Flights
	Convergencies	
27. 1.	1576	1625
15. 2.	1920	1752
2. 2.	?	2156
3. 2.	?	2158
6. 2.	?	2480
8. 2.	?	2424
	Divergencies	
11. 2.	1880	2536
13. 2.	?	2023
14. 2.	?	2535
24. 11.	1040	2781

There are several causes of these divergencies. The situation on 24 November is the easiest to explain. The evening observation (2781 specimens) includes the birds flying over the main observation point, whereas the morning observation (1040 specimens) was made at Mydlniki, in the last section of the flight route, about 4 km. W of the previous point. Only as many birds arrived in this place, for the rest of them stopped on the way there, in fields and along the railway track, as was observed throughout the terminal portion of the route.

Weather also influences the flights in some measure. In the morning on 13 February the temperature was —10°C and there was a strong wind. This may have caused the birds to stop in larger numbers among the buildings along the route. The afternoon was warmer (—3°C) and snowy and 2023 birds were flying then. The next morning was also somewhat warmer (—6°C) and calm. More birds may have reached the end of the route and, as a result, 2535 specimens were returning at a temperature above zero and a clear sky in the afternoon. On 2 and 3 February fine spring weather had persisted since the morning and a similar number of birds flew over. On 6 and 8 February, however, the numbers of the passing birds were unexpectedly at a similar level, though the weather was diametrically different.

The calculations themselves may, in addition, be charged with a grievious error. When the birds fly fast in large compact flocks, the number of the specimens can be determined only by estimate. There is no certainty, either, whether the same numbers of birds fly at a given point of the route each day and then both in the morning and in the afternoon; they may stop along the route in an irregular manner.

VI. MODE OF FLIGHT OF THE BIRDS OBSERVED

Flying in groups, some birds are arranged in definite and relatively lasting formations, e. g., well-known skeins of Cranes and crowded flocks of Starlings. The groups of Rooks and Jackdaws move at the same speed and in a harmonious order. If the Jackdaws, which constitute a minority in these groups, are separated, they form a more compact small flock and fly markedly faster than the Rooks do. Mixed formations of Rooks and Jackdaws are very variable and show a very loose arrangement of specimens, especially in so far as the Rooks are concerned. This last observation is true even of detached pairs of birds. Two Jackdaws always keep close to each other, whereas the Rooks which form a pair may fly 200—300 m. apart.

At calm weather the birds under study fly in an elongated formation, parallel to the flight axis or oriented transversely to it. The first type of formation occurs far more frequently and resembles a trail composed of thinly scattered birds, from some score to several hundred metres in length and 50—100 m. in width. The trail is often reduced to single specimens flying one after another. This last arrangement may be termed a string of birds. The birds of a broad trail move in one, fairly thick, layer of the air; single specimens may, however, swerve temporarily into the under- and overlying lyaers.

The second formation might be likened to a crescent, i. e., a narrow arch oriented transversely to the flight direction. The spread of such a crescent may be 50—200 m. Within a fraction of a minute the crescent can change into a trail.

Trails and crescents do not exhaust the list of formations in which the birds fly. During each flight there appear small groups composed of single pairs or

from several to more than ten specimens, which form irregular loose aggregations. In the morning these groups bring up the rear, in the evening they fly in the forefront.

The height at which the birds fly is hard to determine in absolute values. In this paper the term „low“ means that the birds fly close to the roofs of five-storied houses. The birds pass „high“, when they are still well seen but their voices hardly come to the ground. When the birds fly at a „medium“ height, they are somewhere between the two previous levels.

The picture of both morning and evening flights changed remarkably and depended chiefly on winds. The data concerning the wind direction and speed were obtained from the Meteorological Station at Balice, where the readings were taken every hour at a height of 21 m. and twice a day at a height of 300 m. above the level of the airport. The situation of the Station at the gate of the Rudawa rift valley justifies the application of these readings for the main observation point, which lies 9 km. from the Station, at the bottom of the Rudawa rift valley.

Rectilinear flight, which was the basic mode of movement of the birds at medium and great heights, was observed most frequently. In this type of flight the birds moved their strongly outspread wings rhythmically and seemingly without effort. Even when judged by eye, the movements of wings of Jackdaws appeared somewhat faster than those of Rooks. HERZOG (1968) expressed this more precisely in figures.

It will be seen from Table III that rectilinear flights occurred at calm weather or at small and medium wind-speeds, being independent of the wind-directions. Only in five cases observed the wind-speed exceeded 5 m./sec., reaching 6—7 metres. Similar conditions accompanied the morning and evening flights, and in both these cases the birds might meet with a wind blowing from behind or from in front, which, however, had no effect on the mode of flight.

Undulate flight (Fig. 6) was no rarity, and in it the birds flew at various levels, from the lowest, just over the roofs, to those at considerable heights. Moving their wings quickly, they ascended fairly steeply, then glided on outspread wings slantingly forward and downwards. A moment later, the birds rose again. They flew in this manner without deviating from the assumed direction of flight. In ten cases of such flight the birds were found to fly to their

Table III

Rectilinear flights against the direction and speed of winds

Time of Flights	Wind Direction, in degrees				calm	Total of Flights	Speed of wind in m/sec.		
	045°—135°	136°—225°	226°—315°	316°—044°			0—2	3—5	above 6
Morning	12	1	2	1	1	17	4	9	4
Evening	14	2	7	4	1	28	14	13	1
Total	26	3	9	5	2	45	18	22	5

roosting site with a wind blowing from a direction of 060—090°, and so a tail-wind (Fig. 2). The speed of the wind was 6—11 m./sec. It probably drove the birds down.

Similar undulate flight was also observed in the evening when the wind was frontal. The difference consisted in that the birds tried to make use of it. When ascending, they moved the wings less intensely, but held them outspread in such a fashion as to allow them to avail themselves best of the lifting force of the air current. This type of flight occurred during winds blowing from the 240—280° direction at a speed of 5—7 m./sec. Ascent on outspread wings was also observed each time when the birds flew against a strong gusty wind.



Fig. 6. A diagram showing undulate flight. The flight direction is straight, the flight line undulate, in which the ascent (zigzag line) passes into gliding downwards

The opposite of the quiet rectilinear flight is a type of flight which, being also directed to the west or to the east, proceeds along an undulatory track arching in two, vertical and horizontal, planes at the same time. The birds fly low above the houses, sink into courtyards, squares and streets, and emerge again over the roofs. At the same time the wind drives them to the sides, which they oppose working hard with their wings. The progress is very slow. There is no longer a trail formation of flying birds, but rather a whirl. Such flight may be called a forced one.

Table IV

Dependence of forced flights on strong gusty winds

Time of Flights	Wind-Direction		Total of Flights	Wind-Speed, in m./sec.	
	260°—290°	060°—080°		7—9	10—11
Morning	8	3	11	9	2
Evening	1	6	7	5	2
Total	9	9	18	14	4

Table IV shows that this type of flight was conditioned by strong westerly or easterly winds blowing along the Rudawa rift valley. The force of winds was remarkable, ranging from 7 to 11 m./sec., but what is more, they were gusty, i. e., strong gusts alternated with lighter breaths. The birds either took shelter from the gusts of wind in depressions of the ground or stood up actively against them by assuming an attitude of the body and outspread wings at an appropriate angle to the wind-direction or by flapping the wings. The position of the outspread wings lifted them up, which next allowed them to glide forward and downwards.

At times, several specimens of a train of birds which flew rectilinearly and quietly at medium or great heights began to describe circles on motionless outspread wings and thus rose slowly upwards. Other birds which came flying usually joined them and, in consequence, from more than twenty to above one hundred birds were wheeling. The duration of such a wheeling (gyrating) flight was as variable as the number of wheeling birds. It might be limited to several circles or last for 1—2 minutes. While wheeling, the birds kept to the same place or drifted slowly towards their destination. Finally, they adroitly resumed a trail formation. The groups of birds following them often behaved similarly in the same place. Wheeling was usually done on immobile wings, but sometimes the birds made use of them and performed single beats.

Table V

Dependence of wheeling flight on direction and speed of winds

Time of Flights	Wind-Direction		Total of Flights in Which Wheeling Occurred	Wind-Speed, in m./sec.	
	050°—090°	260°—310°		1—5	6—9
Morning	6	—	6	2	4
Evening	4	10	14	4	10
Total	10	10	20	6	14

Table V allows the addition of several inferences to the statement made previously that it was the birds flying at least at medium heights that wheeled. Roughly speaking, the winds which accompanied the wheeling of birds blew along the Rudawa rift valley. The directions of easterly winds ranged within 50° and those of the westerly winds within 40°. The birds wheeled when the winds blew both from behind and from in front. This could be clearly seen during the afternoon passages, but there is no observation of wheeling birds at a tail-wind during the morning flights. The force of winds is not responsible for the wheeling of birds, as they were recorded at wind-speeds ranging from 1 to 9 m./sec. On the other hand, no wheeling was observed during windless weather.

The birds always wheel against the wind (Fig. 7), regardless of the flight direction, i. e., flying eastwards they can make use of both easterly and westerly winds. Setting their body and wings against the wind, they catch its gusts, which lift them upwards. Probably we are not concerned here with the use of ascending currents of the heated air as in the case of sailplanes, for the birds wheel also early in the morning, when the sun has not heated the earth yet. The number of wheeling groups during one flight is different. In the evening, when the birds were returning more slowly to their roosts, there were more wheeling groups. The most numerous groups of wheeling birds (38) were observed during the evening flight on 4 October 1969. A strong easterly wind was recorded at both altitudes (21 m.: 310° — 8 m./sec., 300 m.: 260° — 9 m./sec.) Drizzle did not prevent a large flock of birds from wheeling in the afternoon of 22 February 1969, the wind-direction being 060° and the speed 3 m./sec. (see also Brown, 1963).

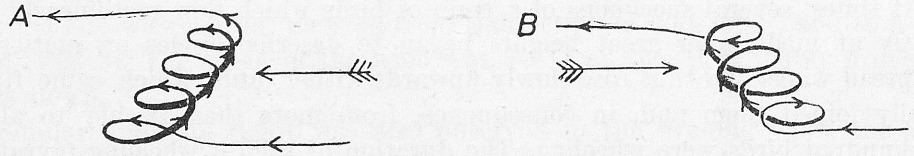


Fig. 7. A diagram of the soaring flight. Birds rise wheeling on motionless outspread wings, lifted by the wind. A — tail-wind, B — frontal wind. The birds catch the lifting force on their wings set against the wind, which is marked by the thickened line

After all, Rooks and some other *Corvidae* are mediocre soarers. They avail themselves of suitable anemological conditions only occasionally, unlike Storks, whose migration routes and nesting sites are associated with areas of good thermal conditions for flight. Kochański (1937) emphasized this fact and designed routes for sailplanes over the areas inhabited by Storks.

Table VI

Percentage share of southern stream in evening flights. The observations are arranged and divided into three groups according to the increasing share of the southern stream in the flights

Date	Total of Flying Birds	Size of Southern Stream (% of Total)	Size Group	Wind		Altitude of Flight
				Direction (in degrees)	Speed (in m/sec.)	
26. III.	3186	12		050°	6	low
15. II.	1752	17		070°	8	medium
11. II.	2536	32	I	060°	7	medium
26. II.	4069	35		060°	4	low
27. VII.	4060	39		070°	6	medium
3. II.	2158	45		260°	9	high
15. III.	2649	48		070°	11	high
23. III.	781	51	II	060°	3	medium
8. III.	2062	53		210°	2	high
2. II.	2156	55		220°	3	high
11. III.	1101	62		250°	6	high
6. III.	3409	67		050°	3	medium
12. III.	3341	73	III	070°	4	medium
31. I.	1580	78		260°	8	high
8. II.	2424	96		calm		high

Waterhouse (1949), who saw the wheeling of Rooks and Jackdaws during their flights, supposes that it helps them to find the proper direction of flight. In Cracow migrating birds also wheeled when they were looking for a place to alight in. However, the birds wintering in Cracow know their everyday flight route well and, while wheeling, they make use of favourable winds.

The main flight route (Fig. 1) is divided into two parallel streams, a southern and a northern. The numbers of birds counted at the main observation point

showed that the percentage of the birds flying in the southern stream varied within wide limits. Out of the 38 observations of evening flights, 15 were chosen and summarised in three groups in Table VI. The first group includes the cases in which a clear minority of birds flew in the southern stream (12—39%). In the second group both streams are more or less equally strong (45—55%) and in the third one the southern stream predominates remarkably in respect of abundance (62—98%). If we take into account all the observations, most of the flights may be included in the first and second group (15 and 14, respectively), the rest of them in the third group (9).

Table VI gives also the direction and speed of winds and the height at which the birds flew. Only in the case of the first group it could be stated that the flight route was shaped under the influence of moderately strong easterly winds. The other two groups showed no influence of either the direction or the speed of winds. The height of flight is not at all connected with the choice of the flight route. Therefore, there is probably another factor, not included in these considerations, which determines this aspect of flights.

VII. RALLYING SITES AND ROOSTS

In the Cracow area there were three or four rallying sites along the east-west line: (1) at Mydlniki, (2) in the Planty, (3) at Łęg, and (4) at Rybitwy. The sites at Mydlniki and Łęg resembled each other in that the birds gathered together in an open area with a small number of trees and in that they were initial sites of rallies. At Łęg the rallying site was in wet meadows and, partly, ploughed fields in the region of the crossing of Nowohucka and Nowogrzegórzecka Streets (Fig. 1, NG, NH). There was one small house and a few clumps of low trees. Observations of rallies carried out twice at this place, at nearly the same time of the year (1 November 1968 and 21 October 1969), and during fine weather either time, are very much alike.

Scattered small groups of birds fed in this region during the day. They began to come to nearly exactly the same place in both seasons 35—30 minutes before the sunset and formed larger flocks on the ground, 200—300 specimens each. Here they fed on or only walked; a few of them alighted in the trees and on the telephone-wires. At different intervals they were joined by small groups which came flying from various sides, chiefly from the west and south. Two or three large flocks came also from the north-west and landed among the birds sitting on the ground or some distance off. When disturbed, e. g., by a flying helicopter, they flushed all together, divided into groups, wheeled and alighted again. They began to leave the site at sunset, when several groups of birds took wing one after another at intervals of several minutes and flew off in the south-eastern direction, towards Rybitwy. This was their departure for the pre-roosting site.

The Rooks and Jackdaws in the Planty (Fig. 8, I and II) behaved in a somewhat different manner. Here they had two final pre-roosting sites of rally and

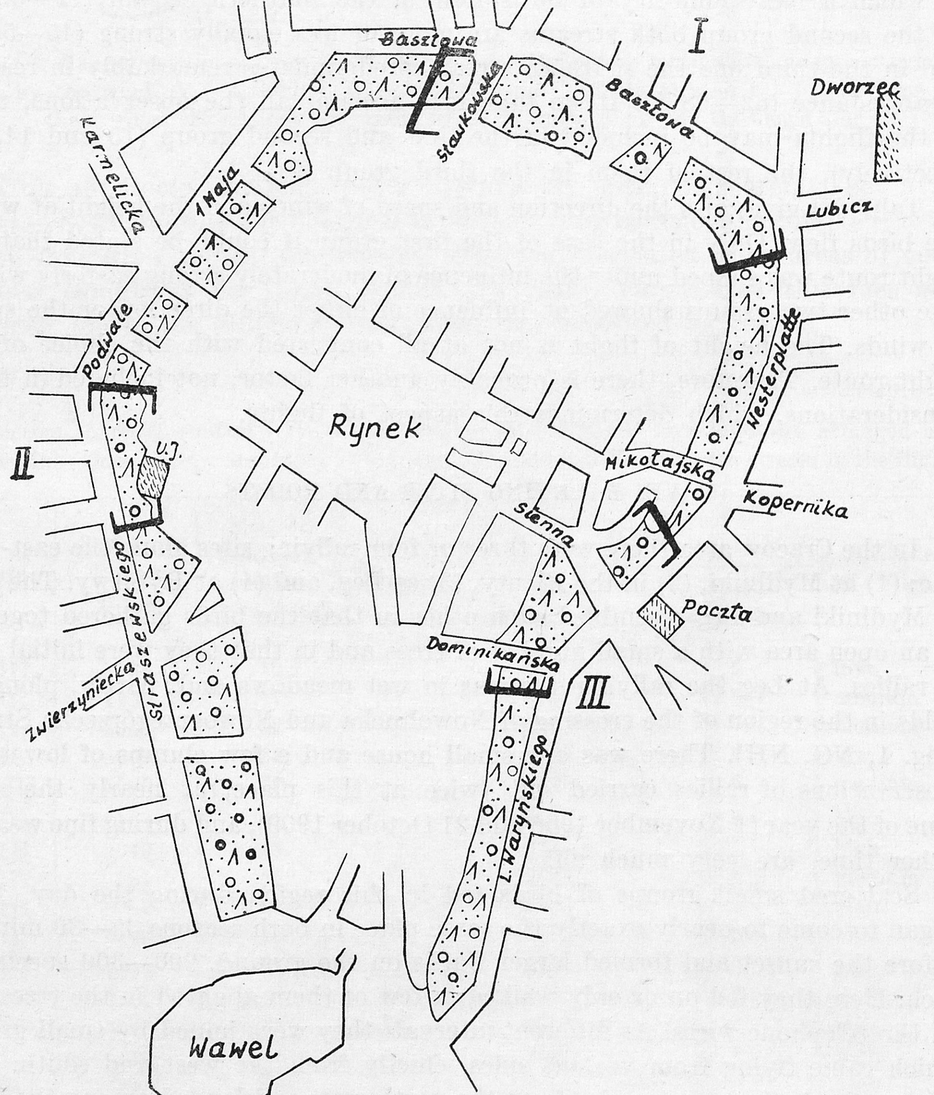


Fig. 8. The situation of the roosting sites in the Planty in September 1969. I — main pre-roosting site, II — secondary pre-roosting site, III — roosting site proper. The boundaries of all the three sites are marked by thick brackets. The drawing is based on a tourist map of Cracow

a roosting site. The first and main rallying site extended from Sławkowska Street to the Theatre. The other one, far smaller, was situated in the vicinity of the main University building. The following description of the behaviour of the birds in the main site of pre-roosting rally may be given on the basis of the observations carried out on 13, 14 and 18 September 1969. The birds alighted in small or medium-sized groups (4—8 and 20—30 specimens, respectively). The birds which had come from the west stayed in the western part of this region of the Planty and those from the east and north in the eastern part. The birds coming from the south appeared, as a rule, only occasionally. Some of the birds, especially Jackdaws, alighted on the roofs of the houses neighbouring on the Planty, from where later they moved to the trees. Small groups of the birds that had already settled took wing and flew to another nearby tree to occupy its top branches. The rallies began 40—35 minutes before the sunset. Flights and not too loud a din lasted until 10—15 minutes after the sunset.

Much fewer birds gathered in the other rallying site in the Planty, near the main University building. At first, some of the birds sat also on the roofs of the neighbouring houses; later, all of them moved to the trees.

A small intermediate site of evening rallies was situated for a short time in the Krakowski Park in the season 1969/70. At about 16^{00} hours a gathering of small groups of birds settling at the tops of the trees was observed twice (18 and 21 January). Jackdaws were more numerous among them than usual and they sat separately in one tree. Flocks of 25—40 birds rose together and flew eastwards.

The departure for the roost from the main rallying site in the Planty proceeded in a similar manner on each of the above-mentioned days. It began 10—15 minutes after the sunset. At that time groups of birds rose from the trees; the first party numbered 150—200 specimens and was followed soon by several more numerous parties. At last, a few single specimens closed up the rear. A whirr of wings and loud din accompanied the departure, while the voices in the trees were dying out gradually. All the birds flew low over the houses straight towards the Post Office, in the neighbourhood of which their roosting site was situated (Fig. 8, III).

According to the observations carried out on 20, 27 and 30 September and 4 October, the birds took 15—18 minutes to settle for roosting. Having come from the rallying sites, the flocks joined together, formed larger groups and circled noisily over the roosting site. They flew off in different directions so far that they passed out of sight, came back again, divided into two or three groups, which circled separately. In the end, they reappeared, but this time low above the trees. In about five minutes they alighted on the trees, which they did first singly, next in small groups and, at last, in masses. Groups of birds flew from one tree to another and there was a loud din for another few minutes. Thirty minutes had elapsed since the sunset when at last the birds

settled down in the trees. Moreover, the last phases of this action took place quite in the dark, lighted somewhat by the street lamps only.

In spite of the din made by them the birds were on the alert for what was happening below. They responded to a sharp whistle by keeping quite quiet for about 5 seconds. When a birdscarer-shot was fired, the birds sitting in the neighbourhood flushed, circled for a short time, and alighted in another place.

The roosting sites in the Planty were marked by a large number of white patches of faeces, densely covering the asphalt lanes, lawns and benches. Thousands of people walking along the lanes failed to rub them off by the evening. There was a strong smell of excreta in these places. On the other hand, the ground of the pre-roosting rallying sites remained nearly quite unsoiled. The area of the roosting site decreased as the number of roosting birds diminished. Its middle part, traversed by Sienna Street, was used longest.

Table VII

Area of the whole Planty and its sections occupied by birds in the evening

Terrain	Area	
	hectares	%
Whole Planty	20·48	100
Pre-roosting site I	4·6	22·7
Pre-roosting site II	0·97	4·7
Roosting site	1·9	9·4
Unoccupied area	13·01	63·2

The total area of the Planty exceeds 20 hectares (Table VII). The birds occupied 27·4 % of it for their pre-roosting rallying sites and nearly 10 % for roosting sites. This indicates that the birds flocked close together for the night rest, which was, besides, revealed by the trees themselves, with their branches bending down under the birds' weight. The birds grouped in the top parts of the trees. It is hard to establish why the birds had chosen these particular three sections of the Planty. There had been no nests there in the spring and most of the nests in the other parts of the Planty had been destroyed during the clean-up in the breeding season. Thus, there was no attractive incitement that, according to different observers (Gramet, 1956; Marshall and Coombs, 1957; Porath, 1964; Rappe, 1964), might encourage the birds to gather or even roost near the nests.

The final pre-roosting rallying sites and the roosting site itself were fixed for the birds of the whole area of Cracow in the autumn of 1969. All the routes of evening flights observed seemed to meet in a park, situated beyond the Vistula embankment at Mogiła. A visit to the park and interviews with the people having their allotments in that region elucidated this matter, at least partly. Throughout the winter of 1968/69 thousands of birds gathered there every evening and roosted in definite oak-trees. The earth was impregnated

with their excreta to the extent that the smell diffused a long way around. In the autumn of 1969 the birds roosted there, too, but they had given up coming to that place for some time. Our walks in the wood on 21 and 26 October and 23 November made it possible to ascertain the lack of any signs of the birds' stay both on the ground and trees, which indicated that the Rooks and Jackdaws had changed their roosting site as they had in the Planty.

Observations made from the Vistula embankment in the neighbourhood of the park for the period of 40 minutes following the sunset on 21 October confirmed the supposition that the birds did not roost there. Instead, large flocks of birds were seen gathering at Rybitwy, on the opposite side of the Vistula. Twenty minutes after the sunset they took wing and most of them flew to the west, only some to the east. These last birds circled over the park entirely in the dark. They also flew westwards 15 minutes later.

Rybitwy as a pre-roosting rallying site needs a short description. There is a very large flat area there, adjacent to the Vistula (Fig. 9). The Płaszów Road traverses it longitudinally, with big factory buildings, some of them under construction, along it. There are also several small groups of dwelling-houses and orchards. Tall trees grow in clumps or rows close to the embankment or right by the river between the 86th and 88th kilometre of the Vistula (measured from its source). Small groups of birds or larger flocks, numbering up to 100 specimens, which came from the south or southwest, alighted (22 November) in the ploughed fields and those of winter corn, situated near the Płaszów Road. The flights commenced as early as 40 minutes before the sunset. As the time passed, the birds which were sitting on the ground flew in groups nearer to the Vistula.

Finally, all of them aggregated there, on the riverside trees, which extend in a row for about 1·5 km. Still at sunset and later large flocks flew from the west, south and north and alighted on the top branches of the trees (Fig. 9.) Large groups of birds moved continually from one tree to another. All these activities were accompanied by a din, in which the voices of Jackdaws predominated. The situation was analogical to that at the main pre-roosting rallying site in the Planty, but here it was on a much larger scale. Half-an-hour after the sunset vast flocks rose from the trees and circled making a din. Part of the flocks soon settled in the Łęg wood, situated on the other side of the Vistula, from where there came a closely localised din. In the end, all the birds moved there.

The next morning (23 November) it was easy to find a large area of the ground and a large number of tree-trunks soiled with the faeces of these birds in the western part of the hornbeam wood. The inhabitants of a nearby house said that the birds had been roosting in this very place for some time.

Thus, in the autumn of 1969 the Rooks and Jackdaws feeding in Cracow and its environs changed the roosting site at Mogiła used in 1968/69 for an entirely new one at Łęg. It is difficult to give the motives which made the birds undertake this. From the human point of view the advantage of the new

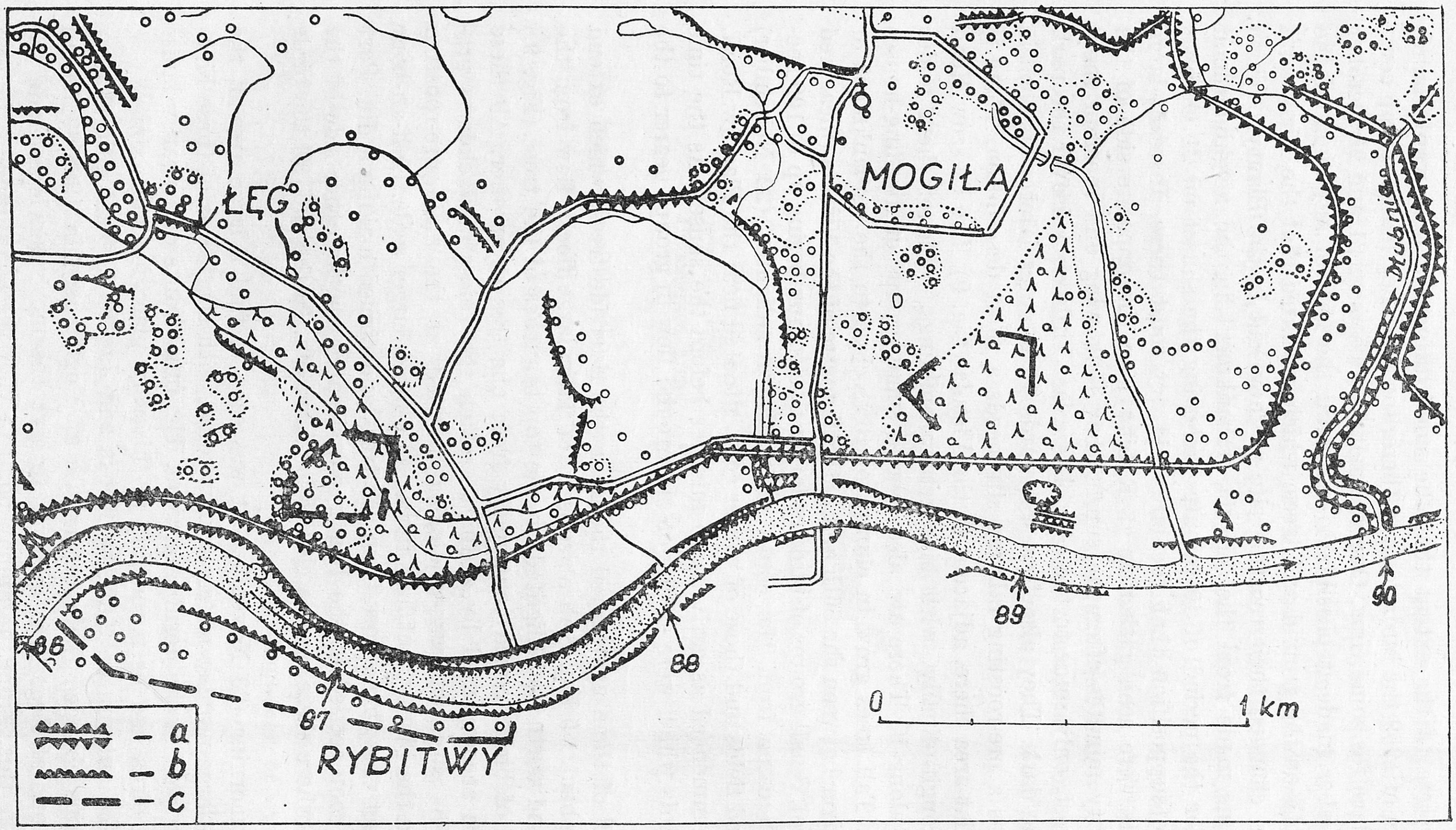


Fig. 9. The situation of the roosting sites in the winters of 1968/69 and 1969/70. The main pre-roosting site of rally of Rooks and Jackdaws from the whole area of Cracow are the trees growing over the space 1·5 km. long on the right side of the Vistula at Rybitwy. The roosting site was situated in the park at Mogiła in 1968/69 and in a young forest at Łęg, 1·5 km. away from the previous one, in 1969/70. a — Vistula embankment, b — river terraces, c — boundaries of rallying and roosting sites. The figures with arrows directed towards the Vistula indicate the distance (in km.) from the sources of the river. The drawing is based on a map provided by Mgr K. Trafas, Institute of Geography Jagellonian University

roosting site is that it provides better shelter from winds. This is so owing to the following conditions: (1) The oak-trees are here relatively young and lower than those at Mogiła. In addition, they form a closer collection. (2) The high Vistula embankment shelters them, at least partly, from southerly and westerly winds. (3) The terrace of the Vistula, buildings and orchards constitute a still better screen on the north side, while the park at Mogiła grows on the open Vistula terrace. (4) The birds do not roost at the edge of the wood, but occupy its middle part, which adds to the protection against winds. (5) The wood lies nearer to the Vistula level than the park at Mogiła does, which secures this first more windless hours or hours of weaker winds.

The observations carried out in Cracow as a rule confirm the findings published by GRAMET (1956), LINT (1964) and RAPPE (1964). The birds under study feed dispersed over a definite area in the daytime. Some dozens of minutes before the sunset they fly off to the rallying site, where they alight either on the ground or on the trees. Hence they fly, directly or through the intermediate sites to the pre-roosting site, where the flocks coming from different sides gather together. They do not move to the roosting sites, which are several hundred metres away, before the dark and settle thickly on the trees, making a very great din. The birds changed their roosting site twice in Cracow. RAPPE (1964) observed at Limburg that the birds moved to a new roosting site, situated at a distance of 300 m., for unknown reasons. The number of the birds roosting together ranges in the sites discussed from several hundred (300—600, RAPPE, 1964) to several thousand (LINT, 1964; GRAMET, 1956) and even to more than ten thousand (12 900, Cracow) specimens, which is probably connected with the expanse of the feeding ground. The times given for various stages of the rally and settling for roosting in relation to the sunset are of a similar order in all these cases.

VIII. SPRING AND AUTUMN MIGRATIONS

The fullest information about the spring and autumn migrations of Rooks and Jackdaws in Poland was given by some English ornithologists, who were kept in the prisoner-of-war camps at Żagań in the Zielona Góra Province and at Szubin in the Bydgoszcz Province during World War II. Twenty-four-hour observations carried out everyday at Żagań showed that the autumnal migrations continued for 52 (1943) and 65 (1944) days in October and November. They reached their peaks in the second week of observation. The spring migrations were shorter, they lasted 35—42 days and fell in the second half of March and in April (WATERHOUSE, 1949). PINOWSKI (1959) mentions the third decade of October and the beginning of November as the period of autumnal migrations in the Warsaw region. Whereas in the years 1955—1959 in the spring Rooks appeared in the nesting colonies in Warsaw between 11 and 26 March (BUSSE, 1965). TUR (1906) gives detailed data concerning the state

of developing eggs in the nests of a large colony of Rooks near Wilanów at mid-April. They indicate that the Rooks appeared there in the second half of March.

In the autumn of 1969 in Cracow Rooks were observed to migrate southwestwards (250°) and, thus, to cross the route of everyday flights (Fig. 2). In the period from 24 October to 6 November they were seen flying high in the morning, at midday and early in the afternoon. The flocks numbered from several dozen to several hundred or even a thousand specimens. Since no daylong observations were conducted, it is impossible to name the day on which the peak of flights occurred.

According to Waterhouse (1949), spring migrations differ in direction from the autumnal ones. In the rift valley of the Rudawa their direction agrees fairly exactly with the route of the birds wintering in Cracow (Fig. 2). Flocks of birds returning from their winter quarters, varying in size, appeared at all times of the day, but mostly in the afternoon, especially towards the evening. These last flocks joined the stream of birds returning from the feeding ground and, naturally, were counted together with them at the main observation point, as will be seen from Fig. 10, which gives a picture of the situation in the second half of February and in March 1969. On some days, following at irregular intervals, the number of birds increased so as to be two or even three times as large. At that time the number of birds flying to the feeding ground was much more uniform and showed a regular gradual fall

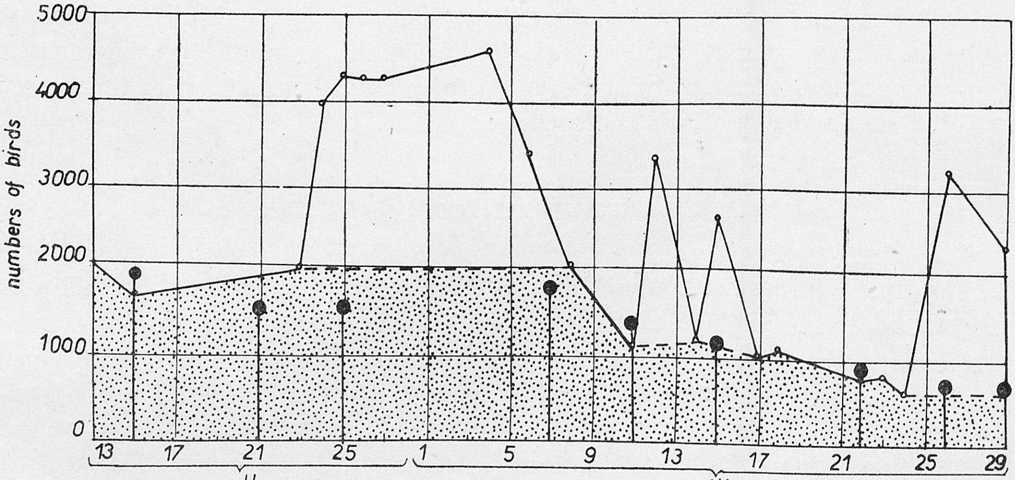


Fig. 10. Daily evening flights (from the west eastwards) and spring migrations in 1969. The days of February and March are marked on the abscissae and the number of birds flying eastwards in the afternoon on the ordinates. The curve line connects the points representing the numbers of birds flying from the west eastwards and the vertical lines ending in black circlets indicate the number of birds flying to the feeding ground in the morning and so from the east westwards. The broken line cuts off the surplus of birds, which are specimens returning from their winter quarters

in March. If the number of birds flying in the morning has been subtracted from that of birds flying in the evening, the remainder, 1500—2500 specimens, will be the birds returning from their winter quarters. The birds flying at other times of the day were not counted and for this reason the observations under discussion make it possible to determine only the period of their return from the winter quarters, whereas the evaluation of its intensity on particular days is fragmentary. Similar, though less systematic, observations were made during the spring migrations in 1970.

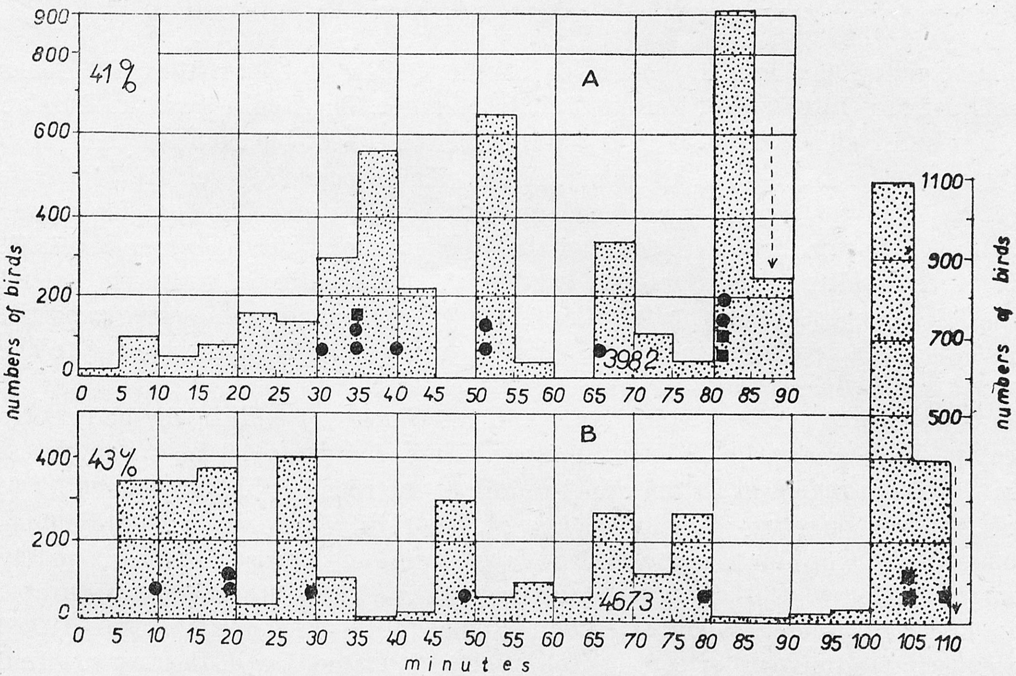


Fig. 11. A picture of evening flights in the spring of 1969 on the basis of the observations made on 24 February (A) and 4 March (B). The time of flight divided into 5-minute sections is given along the abscissa and the number of birds flying in each time group on the ordinate. The percentage of birds flying in the first half of the flight time is given in the upper left-hand corner. The figure in the graph is the total of flying birds. The arrow indicates the time of sunset. Black circlets represent flocks of 100—200 specimens and black squares flocks of more than 200 specimens. The birds returning from their winter quarters distorted the picture of flight, as will be seen from the comparison with Fig. 5

The picture of spring evening flights also changed in this period (Fig. 11). In the first place, the duration of flights extended, in the maximum case, to be twice as long, from 67 to 140 minutes. Two causes contributed to this change. On the days when only the birds feeding in the Cracow area were observed, they were returning singly, in pairs, or in small groups extended in time and space (Fig. 5). On the days when the birds flying from their winter quarters joined them, many of them flew just before the sunset or after it.

On the peak day in this respect, 12 March 1970, more than 1200 birds flew over within 20 minutes following the sunset. The whole passage lasted 140 minutes.

The birds which return from the winter quarters generally form larger and more compact groups consisting of 100, 200 and more specimens. These groups stand out against the loose formations of birds returning from their feeding ground at that time.

IX. SPECIFIC COMPOSITION OF THE POPULATION WINTERING IN CRACOW

Busse (1969) writes that most of the Polish and East-German Rooks migrate for winter to Northern and Central France. The Rooks from the Russian Plain and Baltic S. S. R.-s all fly towards France, too, but some of them stop for winter in Poland and Germany. A fairly large percentage of the Jackdaws (77%) from the regions mentioned undertake migrations but stop for winter at much shorter distances. Some of the Hooded Crows *Corvus corone cornix* L. from the Baltic regions migrate westwards and winter in northern Poland and Germany. Out of the few Crows ringed in Poland, some were reported to have been recovered in Central France, which was the farthest place to the west recorded.

These three species of birds may join into flocks for winter, the percentage composition of the flocks being various. Thus, for example, in a pine forest in the Tartu region in Estonia the number of the roosting birds averaged 5000, of which about two-thirds were Crows, one-third Jackdaws and only 60—300 Rooks. The Jackdaws and Rooks were resident birds, the Crows partly migrants (Lint, 1964; ten-year observations). At the other end of Europe, in Cornwall, there are only resident Rooks (Marshall and Coombs, 1957), without an admixture of continental specimens, for neither of the two external parasites characteristic of Rooks in the rest of Europe was found in them. Their number does not vary from season to season. Nearly throughout the winter they appear near their nests in the morning and in the evening, but they roost elsewhere.

At least 700 birds roosted in the environs of Spa in Belgium; 75—80% of them were migratory Rooks, the remainder included resident Jackdaws and Carrion Crows *C. corone corone* L. There were no Hooded Crows *C. c. cornix* L., which winter there only exceptionally. The roosting site in the Limburg region was visited by about 600 birds, mostly Jackdaws and only a small number of Rooks. Magpies also roosted there, their maximum number being 50 specimens. These, however, did not join the birds of the flock, nor did they respond to their voices, but came and flew away independently of them and at somewhat different times (Rappe, 1964). According to Gramet (1956), in France flocks numbering 3000—5000 Rooks, Jackdaws and Carrion Crows roosted north of Paris (Devron and Grignon).

In Poland flocks of Rooks and Jackdaws were observed during spring and autumn migrations at Żagań. The share of Jackdaws in these flocks was estimated at 10% (Waterhouse, 1949). In Cracow the flocks consisted only of Rooks and Jackdaws, but out of the town, e. g., at Zawoja, there occurred flocks which were composed chiefly of Hooded Crows and a smaller number of Jackdaws, but without any Rooks. In the Cracow area several Magpies could be seen on the flight route in the rift valley of the Rudawa everyday. In the evening they appeared in the first phase of flight and flew straight to the south and so perpendicularly to the route of the Rooks and Jackdaws. In the morning they turned up when the Rooks and Jackdaws had already scattered over the area. The flight of the Magpies showed no major influence of their meeting these last birds.

It is difficult to determine the numerical relation of Jackdaws to Rooks in a flying flock, for they fly too high or too fast and in too crowded and large a group. Two attempts were made to ascertain the composition of a flock flying eastwards on a fine day and the results obtained were similar. On 12 October 1969 the Jackdaws formed 10% of the about 500 birds and on the next day there were 19 (9%) Jackdaws and 216 Rooks. The birds settling for roosting on leafless tree branches in the dark were seen at best as indistinct silhouettes and their species could not be identified.

The birds waiting for food in the Krakowski Park were counted several dozen times. It appeared that the Jackdaws formed at most 5% of the 120—150 birds counted. They were also counted twice, using field-glasses, in flocks sitting on the ground at the site of evening rallies at Łęg. In the groups of about 200 specimens there were, respectively, 8 and 20 Jackdaws. In the flocks of birds flying in the morning and in the evening the Jackdaws were mixed up with Rooks ununiformly. It could be discerned aurally that the Jackdaws flew in small groups; calls of single pairs could also be heard at irregular intervals amidst the train of Rooks. If despite these reservations the present observations of sitting and flying birds may be generalised for the whole population of wintering birds, the proportion of Jackdaws should be determined at 5—10%. At any rate, Jackdaws are far fewer then Rooks.

The foregoing considerations show that in the winter Rooks, Jackdaws and Crows may join into flocks, which roost and feed together. Though the Magpies meet with these birds in the daytime, they retain a perfect independence of movements, which may be due, among other things, to the fact that they fly much more slowly and less persistently. The specific and percentage composition of a flock wintering in a given area depends chiefly on the proportion of the nesting birds flying westwards to their winter quarters and on the specific and percentage composition of the flocks coming for winter from the east. Wintering flocks may include one, two or three species.

X. DIET OF WINTERING BIRDS

VERTSE (1943) gave a detailed description of the diet of Hungarian Rooks for particular months and estimated the usefulness and harmfulness of these birds for human husbandry. LOCKIE (1955) and MARSHALL and COOMBS (1957) paid attention to the fact that the abundance of earthworms exerts an influence, in addition to other factors, on the commencement of ovulation and successful breeding of the young. PINOWSKI (1959) and PORATH (1964) state in agreement that Rooks, as a rule, feed in cultivated fields with low vegetation, meadows and stubble or ploughed fields. In November, after the first frosty days, they move to refuse dumps and built-up town areas, where they feed until the spring.

Table VIII

Weather conditions in Cracow in the winters of 1968/69 and 1969/70
(after MERTA, 1970)

Year	1968/69				1969/70			
Month	XII	I	II	III	XII	I	II	III
Days with ground frost	30	29	22	27	31	29	26	23
Mean temperature	—4·6	—6·6	—2·5	—1·0	—6·9	—5·0	—3·9	—1·3
Days with snow-cover	20	28	19	11	31	31	28	20
Thickest snow-cover, in cm	6	7	18	7	36	31	37	44

The main difference between the two winters consisted in the duration and thickness of snow-cover.

These last remarks refer also to the situation in Cracow, where the Rooks and Jackdaws do not leave the open areas until they have been discouraged by the continuous snow-cover. The temperatures and snow-fall of Cracow during the two periods of observation are presented in Table VIII, which shows that in these two winters the number of days with morning ground frost and the mean monthly temperatures were rather similar, whereas the winter of 1969/70 had considerably more days with snow-cover, the thickness of which was also markedly greater. Hence, the winter of 1969/70 suited better for the estimation of the influence of the temperature and snow-cover on the ways of living of these birds than the same period of the preceding year. The constant observation area extended between the Krakowski Park, the Jordan Park and Piastowska Street (Fig. 1, K, J, P). In this area there are houses standing close to each other and scattered houses, gardens, two parks, meadows and cultivated fields.

Towards the end of August and at the beginning of September there were no Rooks in this area, but a few Jackdaws used to sit on the roofs and aerials and visited the courtyards. In the second and third decades of September more and more numerous Rooks began to feed in the open areas and single

specimens appeared on the roofs and in the courtyards. The same situations was observed in October only that the number of Rooks and Jackdaws feeding in the courtyards was on the increase. At the end of October and at the beginning of November the first Rooks and Jackdaws, few in number, appeared in both parks and fed on the ground (Fig. 12). There were about 20 specimens in the Jordan Park and only half as many in the Krakowski Park. In the second

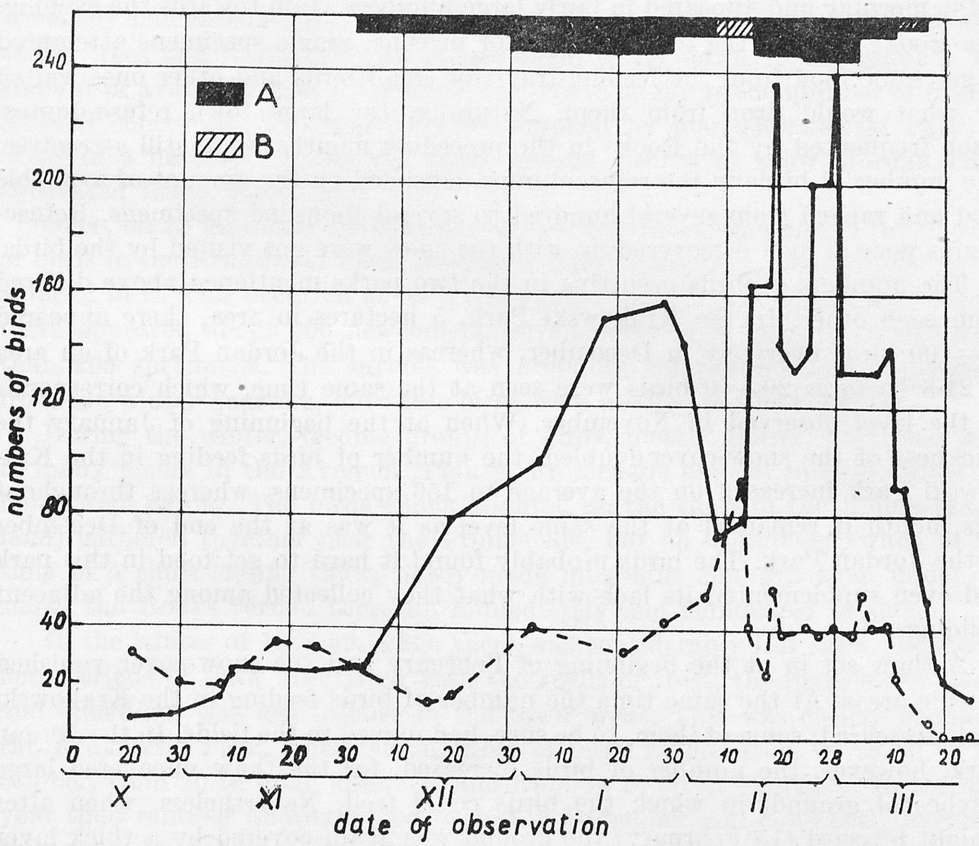


Fig. 12. Influence of weather on the number of birds in two parks. (1969/70.) Months and days are given along the abscissa, the numbers of birds along the ordinate. Solid line — observations in the Krakowski Park, broken line — observations in the Jordan Park. A — occurrence of snow- cover, B — thaw. The birds were counted in the Krakowski Park mostly at 08^{30} hours, in the Jordan Park at 14^{00}. The time of counting in the parks was sometimes reversed

and third decades of November most of the birds still fed in the open areas, out of the built-up places, but somewhat more of them visited the courtyards. A little more birds also searched for food under dead leaves and amidst damp grass in both the parks mentioned.

The situation changed at the begnining of December. The weather became frosty, the earth froze and soon was covered by a continuous layer of snow.

This state kept till March with the exception of two very short spells of thaw. The birds immediately began to encroach on the built-up areas. In the morning pairs or small groups of them separated from the flocks flying westwards, dived and alighted on the roofs or right in the courtyards, near the rubbish-bins. The Rooks were particularly bold in searching different nooks and corners and picking out garbage. In this period 10—20 birds could be seen in a medium-sized courtyard in the morning hours. It was there that most of the birds fed in the morning and appeared in fairly large numbers again towards the evening. The Rooks ate also the food laid out for pigeons. Single specimens attempted to get some food from the feeding-trays for small birds and other ones waited for what would drop from them. Naturally, the large town refuse-dumps, much frequented by the Rooks in the preceding months, were still attractive. The number of birds in the refuse-dumps depended on the amount of available food and ranged from several hundred to several thousand specimens. Refuse-dumps poor in food or covered up with the snow were not visited by the birds.

The numbers of birds occurring in the two parks mentioned above differed from each other. In the Krakowski Park, 5 hectares in area, there appeared 70—100 birds everyday in December, whereas in the Jordan Park of an area of 21·8 hectares 20—40 birds were seen at the same time, which corresponds to the level observed in November. When at the beginning of January the thickness of the snow-cover doubled, the number of birds feeding in the Krakowski Park increased on the average to 150 specimens, whereas throughout this month it remained at the same level as it was at the end of December in the Jordan Park. The birds probably found it hard to get food in this park and even supplemented its lack with what they collected among the adjacent buildings.

A thaw set in at the beginning of February and the snow-cover vanished in wide areas. At the same time the number of birds feeding in the Krakowski Park decreased; some of them, to be sure, had moved to the fields. In the Jordan Park, however, the number of birds increased, for the thaw uncovered large patches of ground, in which the birds could feed. Nevertheless, when after a night blizzard (15 February) the ground was again covered by a thick layer of snow, the number of birds in both parks reversed (Fig. 12). It increased to 160 specimens in the Krakowski Park and decreased to 40 in the Jordan Park. On particular days following a fresh snow fall the number of Rooks in the Krakowski Park rose to 240 specimens. In March, when the snow-cover became thinner, it diminished again.

The fluctuations in the numbers of birds feeding in both parks are not dependent on the size of the parks or the density of trees. The Jordan Park is four times as large and has wide areas with few or no trees at all, and for this reason it should feed more birds. That it is not so is due only to the fact that they receive additional food from people in the Krakowski Park. Fewer people walked through the Jordan Park and they did not visit all its lanes. There were few feeding-trays in this park and the existing ones were poorly provided with

food if they were provided at all. On the other hand, quite a lot of people walked through the Krakowski Park. Some of them regularly laid food out in the feeding-trays for small birds. Others poured out scraps of the kitchen or crumbled bread in less frequented parts of the lanes. Sitting low on the tree branches or on the ground, the Rooks waited for these moments. When the feeder moved a few steps away, 20—30 birds immediately dashed at the food and other birds soon flew there from the outlying parts of the park. About midday the birds obviously had satisfied their hunger, since they settled themselves at the tops of the trees and it was hard to induce them to fly down to the ground. The amount of available food is therefore decisive in so far as the number of feeding birds is concerned. The food may be supplied by man (Krakowski Park) or occur in a natural way on the damp ground cleared of snow (Jordan Park, cultivated fields, meadows).

Once, on 23 February 1970, there was a short-lasting increase in the number of birds in the Krakowski Park, because a flock flying from the winter quarters stopped in it. This occurred at 08^{30}, when in addition to 140 specimens counted there appeared about 200 newcomers. Seven hours later there were still more than 200 specimens. The surplus was probably composed of the newcomers from the winter quarters, but these birds were missing on the next day.

During the winter, feeding groups of birds, mostly Rooks, were met with in many places in the Avenues, Planty, Promenade and all squares, while the fields were empty. The birds which alighted on the snow in the Błonia (grassland) gathered together near the Promenade, but on 6 January, when at the time of a short-lasting thaw, newly-made mole-hills emerged from under the snow, the Rooks turned there up immediately and rummaged in them.

In the winter of 1968/69, when there was considerably less snow and rather long periods of thaw alternated with the spells of frost, the invasion of Rooks and Jackdaws was less intense in the town areas. This was clearly visible in the Krakowski Park, where the number of birds ranged from 20 to 60 in December, from 20 to 90 in January, and from 40 to 95 in February. In the next year their number approximated to 100 in December and constantly exceeded this value in January and February. However, apart from the parks, most of the birds fed wherever they did in 1969/70. If, owing to a thaw, black or green patches of ground appeared from under the snow, the birds immediately visited them, both in the Błonia and in the fields, and attempted to feed.

Food of the wintering birds was obtained chiefly from rubbish-bins, part of it was also gathered from the ground in squares, parks and cultivated fields, if it was not covered by a continuous layer of snow. It is worth while to make an attempt to estimate, naturally quite roughly only, how much of such food is consumed by the Rooks wintering in Cracow. All the estimates in this respect concerning their population are given in this paper and the bioenergetic parameters must be assumed on the basis of the general physiological principles.

Above 11,500 Rooks winter in Cracow (Table IX). The birds stay in the town area for about 166 days, from the beginning of October to mid-March. Multiply-

Table IX

Estimation of the aboundance of the winter Rook population in Cracow

Date	Flight Route	Number of Birds
4 Oct.	Botanical Gardens	3339
20 Oct.	Płaszów	4420
21 Oct.	Prądnik	2670
1 Feb.	Hospital at Mogiła	1044
1 Dec.	Łęg	1453
1969/70	Total	12926
	less 10% for Jackdaws	1293
	Total of Rooks	11633

ing the number of Rooks by the time of their stay here, we calculate the number of bird-days, which is large, 1.931,078.

The body weight of Rooks wintering in Western Europe has lately been determined on the basis of fairly abundant material (Bährmann, 1960; Focke, 1966; Steiner, 1969). There are big differences in weight between birds in the first year of life and the adult ones, and within these two groups between sexes. The body weight decreases to reach its minimum in December and January, but in general it depends on the amount of available food in the rubbish-bins. An average body weight of 480 g may be assumed for the Rooks wintering in Vienna (Steiner, 1969) and probably it may also be applied for the Cracow Rooks. Thus, the average biomass of the Rooks wintering in Cracow is above 5,5 metric tons (5,584 kg.).

The costs of maintenance of homaeothermic animals are sometimes assumed to be three times as high as their basal metabolic rate (Golley, 1967). In the case of wintering Rooks this assumption is not an over-estimate. In winter Rooks' heat production for thermoregulation must be intense and, besides, these birds must dissipate much energy for daily flights, 8—15 km. one way, and for many-hour active search for food.

The standard metabolic rate of birds is a well-known function of their body weight. This function has recently been determined by Lasiewski and Dawson (1967) and Zar (1968) for the *Corvidae*. According to it, a bird weighing 480 g. has a standard metabolic rate of 75 kg. cal./day. Thus, its costs of maintenance (3 times as large) are probably about 225 kg. cal./day. The actual consumption of the Rook will be higher by at least 30%, because the metabolizable energy of birds amounts to about 70—90% of the energy of their food intake (King and Farner, 1961). Rooks pick out their food from refuse and it is of very low digestibility. Hence, the daily food consumption of the Rook is about 320 kg. cal./day in the winter.

Multiplying this last value by the total number of bird-days, we shall obtain the consumption of the population of Rooks wintering in Cracow. From the

beginning of October to mid-March this population should consume nearly 618.000,000 kg. cal. (618×10^6 kg. cal.). This is an equivalent of about 772 tons of potatoes, or 562 tons of giblets, or 281 tons of bread (Rudowska-Koprowska, 1954).

The Rooks convert nearly 434×10^6 kg. cal. to heat and lose them in life processes, whereas the remainder, 184×10^6 kg. cal., is expelled in the form of faeces and pellets, which form about 142 tons of fresh dung or 53 tons of its dry matter. Owing to this huge energy flow, the population of wintering Rooks accelerates also the rotation of matter, which is of importance to the husbandry and sanitary conditions of a big town. Rooks clear the refuse-dumps from organic substances, which, decaying, would otherwise contaminate the air in the town. Their faeces dropped along the routes of flights and in the feeding-grounds fertilise the soil. A harmful effect of intensive manuring with them became manifest only at the roosting sites.

This effect could be observed in the Łęg wood towards the end of April 1970. Everywhere in it but in the roosting site young exuberant grass spread among the trees. There was nearly no grass under the trees in which the Rooks and Jackdaws roosted; instead, numerous completely bare patches, 1—3 sq. m. in area, were conspicuous. *Aegopodium podagraria* L. and also small and thin tufts of *Pulmonaria obscura* Dum. grew well among scarce shoots of grass between them. In the naked places there were still many inorganic remnants of the pellets, whereas the faeces, probably washed away by rain-water, had disappeared entirely. The scarcity of vegetation was connected with the excess of nitrogen compounds provided to the soil by the birds.

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STRESZCZENIE

Obserwacje gawronów i kawek zimujących w Krakowie prowadzone były w latach 1968/69 i 1969/70. Stado gawronów i kawek zimujących w okresie 1969/70 oceniono na ok. 13 000 sztuk. Pierwsze gawrony pojawiły się na terenie miasta pod koniec sierpnia. Kawki, być może osiadłe, zbierały się w tym czasie w małe stadka. Liczba tych ptaków rosła z wolna i na początku października była już przypuszczalnie pełna populacja zimująca. Strefa żerowania obejmowała początkowo głównie części nie zabudowane i nie zadrzewione. Specjalnie atrakcyjne były dla nich wielkie śmietniki miejskie. Między zabudowaniami pojawiały się wtedy stale kawki i nieliczne gawrony. Przez październik i listopad rosła tam stale ich liczba. Ale dopiero od pierwszych mrozów i śniegu, który w r. 1969 z początkiem grudnia pokrył zwartą warstwą ziemię, nastąpiła inwazja tych ptaków w właściwą strefę zabudowań. Ponieważ pokrywa śnieżna utrzymała się przez całą prawie zimę bez dłuższych przerw, stosunki te ustaliły się. Względna łatwość zdobywania pokarmu decydowała o tym, gdzie ptaki gromadziły się liczniej. Zjawisko to było najlepiej uchwytne w dwu parkach miejskich, oddalonych od siebie o kilkaset metrów.

Wszystkie zimujące w Krakowie ptaki zbierały się w jednym miejscu i nocowały na drzewach, obsiadając gęsto górne gałęzie. Rano rozlatywały się na żerowiska stadami po ustalonych trasach. Tras tych było pięć, z nich jedna 15 km długa ciągnęła się mniej więcej w osi wschód-zachód, od Mogiły lub Łęgu ponad centrum miasta do Mydlnik bądź Bronowic Małych. Trasy przelotu dostosowały się do konfiguracji terenu. Ptaki wybierały najspokojniejszą strefę powietrza w Krakowie, osłoniętą od północy i południa wzgórzami (rys. 1).

Poranne przeloty rozpoczynały się jeszcze w całkowitej ciemności i trwały przeciętnie 35 minut, przeciągając się nieco poza wynurzenie się słońca z poza horyzontu. Wieczorem początek przelotów wyprzedzał znacznie zachód słońca i trwał przeciętnie 67 minut (rys. 3). Ptaki lecące na żerowisko spieszą się bardziej niż z powrotem na nocleg; większość przelatuje rano w pierwszej połowie podanego czasu, natomiast wieczorem w drugiej połowie (rys. 4, 5).

Stada ptaków wyciągały się podczas przelotów w smugi różnej długości i szerokości. Rzadziej rozciągały się w tyraliery ustawione prostopadle do kierunku lotu. Podczas ciszy lub wiatru o średniej szybkości (5 m/sek), bez względu na jego kierunek, lot jest spokojny i prostolinijny, na różnej wysokości (tab. III).

Przy wiatrach silnych (7—11 m/sek) i porywistych ptaki lecą nisko i wolno, chroniąc się przed podmuchami w zagłębieniach podwórzy, placyków i ulic (tab. IV). Wiatry mocne lecz nie porywiste ptaki pokonują lotem falistym (rys. 6). Ptaki wykorzystywały wiatry równe, tylne lub przednie, do krótkiego i lokalnego szybowania (rys. 7, tab. V), dzięki czemu zyskiwały na wysokości.

Zimujące gawrony i kawki mają swoje stałe miejsca noclegowe, w których zbierają się rokrocznie. W okresie 1969/70 gromadziły się na Plantach w centrum miasta, zajmując mniej niż 10% ich powierzchni, stale w tym samym miejscu. Od października przeniosły się 7 km na wschód do lasku nadwiślanego w Łęgu. W okresie ubiegłym nocowały w tamtych stronach o 1,5 km dalej na wschód. Nastąpiła więc podwójna zmiana noclegowiska, której przyczyn nie da się wskazać.

Ptaki te nigdy i nigdzie nie zbierają się wprost na miejscu noclegowym. Istnieją osobne przednoclegowe miejsca zbiórek, gdzie zlatują się ptaki jeszcze przed zachodem słońca. W przypadku krakowskim był to inny odcinek Plant bądź sznur drzew rosnących nad Wisłą w Rybitwach. Z tych miejsc już dobrze po zachodzie słońca przenosiły się wszystkie do właściwego miejsca noclegowego (rys. 8, 9). Zbiórkom w miejscach przednoclegowych a szczególnie noclegowych towarzyszy wrzawa o natężeniu odpowiadającym liczbie ptaków.

Na przedwiośniu, w lutym/marcu, ptaki ciągnące z zimowisk w Europie zachodniej na gniazdowiska na wschód (rys. 2) zniekształcały obraz przelotów na głównej trasie z żerowiska na nocleg. Odnosi się to zarówno do czasu trwania przelotu (rys. 11), jak i liczby ptaków (rys. 10).

Próbowano określić szacunkowo, ile pokarmu skonsumowały gawrony w sezonie 1969/70. Ponad 11,5 tysiąca gawronów (tab. IX) przebywało na terenie Krakowa przez około 166 dni. Przyjmując przeciętny ciężar ciała jednego osobnika na 480 g można obliczyć, na podstawie wzorów opracowanych przez fizjologów, jego konsumpcję dzienną na 320 kcal. Konsumpcja całej populacji w okresie zimowania wyniosła około 618 milionów kcal, co odpowiada około 772 tonom ziemniaków.

РЕЗЮМЕ

Наблюдения над грачами и галками, зимовавшими в Кракове были проведены в 1968/1969 и 1969/1970 гг. Стаю грачей и галок, зимовавших в 1969/1970 гг. оценено на 13000 штук. Первые грачи появились на территории города в конце августа. Возможно, поселившиеся галки, собирались в это время в маленькие стаи. Количество этих птиц медленно возрастало и в начале октября была уже, вероятно, полная зимующая популяция. Вначале они добывали пищу в местах, где не было построек и деревьев. Особенно их привлекали городские мусорные ящики. Тогда между постройками появлялись галки и немногочисленные грачи. В течение ок-

тября и ноября их количество постоянно возрастало. Вторжение этих птиц в зону построек произошло лишь после первых морозов и снега, который в 1969 г. в начале декабря покрыл сплошным слоем землю. Так как снежный покров удерживался почти через всю зиму без более длинных перерывов, эта связь установилась. Где легче было добывать пищу, там в большем количестве собирались птицы. Эта зависимость была особенно заметна в двух городских парках, расположенных друг от друга в нескольких сот метрах.

Все зимующие в Кракове птицы собирались в одном месте и ночевали на деревьях друг возле друга на верхних ветках. Утром разлетались за добычей пищи по установленных трассах. Этих трасс было 5. Из них одна, длиной 15 км тянулась более менее в оси восток-запад, с Могилы или Ленга над центром города к Мыдльникам или Броновицам Малым. Трассы перелёта приспособились к рельефу местности. Птицы выбирали наиболее спокойную зону воздуха в Кракове, прикрытую из севера и с юга возвышенностями (фиг. 1).

Утренние перелёты начинались в полной темноте и продолжались в среднем 35 минут, растягиваясь незначительно за появление солнца из-за горизонта. Вечером, начало перелётов значительно опережало закат солнца и продолжалось в среднем 67 минут (фиг. 3). Птицы, летящие за кормом более спешат, чем обратно на ночлег; большинство перелетает утром в первой половине поданного времени, а вечером во второй половине (фиг. 4, 5).

Стаи птиц вытягивались во время перелётов в полосы различной длины и ширины. Реже растягивались в растянутые цепи, установленные перпендикулярно к направлению лёта. В тиши или во время ветра со скоростью 5 м/сек, несмотря на его направление, лёт был спокоен и прямолинейный, на различно высотей (табл. III). При сильных ветрах (7—11 м/сек) и порывистых птицы летели низко и медленно, прячась перед порывами ветра в углублениях двориков, площадок и улиц (табл. IV). Сильные, но не порывистые ветры птицы преодолевают волнообразным лётом (фиг. 6). Птицы использовали ровные, задние или передние ветры к короткому и местному парению (фиг. 7, табл. V), благодаря чему выигрывали на высоте.

Зимующие грачи и галки имеют свои постоянные места ночлега в которых собираются ежегодно. В период 1969/1970 гг. собирались на бульварах в центре города, занимая менее 10% их поверхности, постоянно в одном месте. С октября перенеслись 7 км на восток в привислинский лесок, в Ленге. В прошлый период ночевали в том районе 1,5 км дальше на восток. Произошла, таким образом, двойная перемена ночлега, причины которой не известны.

Эти птицы никогда и нигде не собираются непосредственно на месте ночлега. Существуют отдельные предночлеговые места сбора, куда прилетают птицы ещё до заката солнца. В краковском случае это был другой отрезок бульваров или полоса деревьев над Вислой в Рыбитвах. С этих мест, после заката солнца, все птицы перелетали к настоящему месту ночлега (фиг. 8, 9). Во время слёта в предночлежные и особенно ночлежные места птицы громко кричат.

Накануне весны, в феврале/марте, птицы, возвращающиеся из зимовок в западной Европе на гнездовья на восток (фиг. 2) искажали картину перелётов глав-

ной трассы с корма на ночлег. Это относится ко времени продолжительности перелёта (фиг. 11) и количеству птиц (фиг. 10).

Пробовали определить оценочно количество корма, употребляемого грачами в сезоне 1969/1970 гг. Более 11,5 тысяч грачей (табл. IX) находилось в Кракове около 166 дней. Принимая средний вес одной особи 480 г, на основании формул, выведенных физиологами, можно подсчитать, что она употребляет 320 ккал. Для всей популяции консумпция в период зимовки составляет около 618 миллионов ккал. что соответствует 772 тоннам картофеля.

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